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An Evaluation of Economic-Demographic Models for Impact Assessment of Nuclear Waste Repository Development at Hanford, Washington

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EXECUTIVE SUMMARY

This report describes the evaluation and selection of an economic-demographic (ED) model to support the Basalt Waste Isolation Project (BWIP) socioeconomic program. The ED model is a component of the Socioeconomic Impact Assessment investigations that will be developed over the next 2 years. This report summarizes the ED program objectives, presents an overview of integrated modeling in regional analysis, presents criteria used for evaluating candidate models, and describes in detail the three candidate models that come closest to meeting program objectives. A strategy is then presented for producing an operating model over the next 2 years that is tailored to the Tri-Cities economy and the economies of the affected Indian tribes, with the potential to model an expanded study area if warranted.

ED models have been refined for planning and impact assessment over the past 20 years. Their structure typically includes

- an economic module, which produces economic forecasts for a region, including demand for labor (i.e., employment) .
- a demographic module, which produces not only population by age and sex, but the supply of labor (by applying labor force participation rates to age/sex cohorts)
- a labor market (or ED interface) module, which compares labor supply and demand, and invokes migration in or out of the study area to produce equilibrium in the labor market and (sometimes)
- a subarea allocation module, which produces demographic and economic forecasts for cities and other subcounty jurisdictions. (A subarea allocation procedure will be necessary for the BWIP.)

The evaluation of available models and BWIP modeling objectives yielded the following conclusions:

- No single "off-the-shelf" modeling package is currently available to adequately meet program objectives.

- Three models come close to meeting program objectives.[a]
- The FS-53 economic module, a major element of the ED model, is judged to be superior--indeed, state of the practice. The FS-53 model does not have available a subarea allocation module, however, and its demographic module has not yet been field tested. Both SEARS and PAS have subarea allocation and demographic modules.
- A hybrid model that takes advantage of the respective strengths of the models for each specific BWIP application will be developed. This model could be either a FS-SEARS or FS-PAS hybrid, with modifications as needed to fulfill BWIP program objectives.
- The FS-53 economic model should be selected for BWIP county-level analysis for fiscal year (FY) 1987.
- Further evaluation of the FS-53 demographic module should be undertaken during FY 1987.
- The PAS and SEARS models should be further evaluated during FY 1987 and FY 1988.

Extensive revisions of SEARS are under way, sponsored by the U.S. Department of Energy's (DOE) Salt Repository Project Office. As a result, ratings can only tentatively be assigned to the SEARS model. It will be reviewed again after revision in FY 1988. Using the FS model during FY 1987, rather than waiting until SEARS model revisions are completed, will help satisfy BWIP short-term needs for modeling capabilities without foreclosing the option of using all or part of SEARS once scheduled revisions are completed.

(a) These models, chosen for detailed evaluation for use in the BWIP program, were the Planning and Assessment Model (PAS) developed by Mountain West Research-Southwest, the Forecasting and Simulation (FS) model produced by Regional Economic Models Inc. (REMI) and the SocioEconomic Analysis of Repository Siting (SEARS) model developed by the Texas Agricultural Experiment Station.

CONTENTS

1.0 INTRODUCTION

1.1 ORGANIZATION

This paper is a review and evaluation of the various models available for assessing the socioeconomic impacts of site characterization for, and construction and operation of, a high-level nuclear waste repository at Hanford, Washington. The goals of the project and a description of the affected economies are discussed in this Introduction. After a brief discussion of the historical use of integrated economic-demographic (ED) models in regional analysis (Section 2.0), an overview of their structure is presented (Section 3.0). Eight criteria used to select the models are then detailed (Section 4.0). The alternative models are described (Section 5.0), evaluated, and the preferred models are recommended (Section 6.0). Finally, steps to resolve issues are described (Section 7.0).

A brief description of the goals of the economic/demographic tasks of the BWIP and the nature of the economies to be modeled follows.

1.2 GOALS FOR THE ECONOMIC AND DEMOGRAPHIC TASK

The economic and demographic task must fulfill the information needs for 1) impact management planning for site characterization, 2) the radiological assessment program, and 3) if acceptable in terms of comparability among sites, the socioeconomic assessment for the Environmental Impact Statement (EIS). These information needs are discussed in greater detail in Section 4.0. Generally, a method is needed for discerning the economic processes by which the employment and purchases made during site characterization would be transformed into impacts. The estimates of these impacts will be used by other socioeconomic tasks, particularly for evaluating public services and social factors. In addition, the radiological assessment program will require population projections for the area within 50 miles of the site.

The goals of the economic and demographic task over the 3-year period from FY 1987 to FY 1989 include:

1. develop the project data base to facilitate use of the ED model, and produce economic and demographic profiles (1987)

2. select and link an ED model with a subarea allocation model (1987-1988)

3. produce an ED model in a manner that will allow an orderly task schedule (1987-1988)

4. produce a model that will be ready for preoperational use when worker survey data are available for county-level analysis (beginning late FY 1987 or early FY 1988)

5. potentially produce a model that can support licensing and eventual production of an EIS.

To achieve these goals, progress must be made on developing an ED model during FY 1987. During the remainder of FY 1987 the 3-year work plan will be refined. By the end of FY 1988 an operational ED model will be produced, fine tuned, and used in conjunction with BWIP worker survey data. By FY 1989 the model will be used to estimate the impacts of site characterization and potential repository development.

1.3 BRIEF CHARACTERIZATIONS OF THE POTENTIALLY AFFECTED ECONOMIES

Four areas have been identified for economic-demographic modeling for BWIP: 1) the Benton-Franklin Metropolitan Statistical Area, Washington, where the Hanford Site is located; 2) Yakima County, Washington, where the Yakima Indian Nation reservation is located; 3) Umatilla County, Oregon, home of the Confederated Tribes of the Umatilla Indian Reservation; and 4) Nez Perce, Lewis, Clearwater, and Idaho Counties, Idaho, home of the Nez Perce Tribe (Figure 1). The latter three of these areas have been identified for analysis pursuant to the determination by the Secretary of the DOE that the Yakima, Umatilla, and Nez Perce are "affected Indian tribes" for the purposes of the Nuclear Waste Policy Act. The following is a brief characterization of the economies and populations of these four areas.

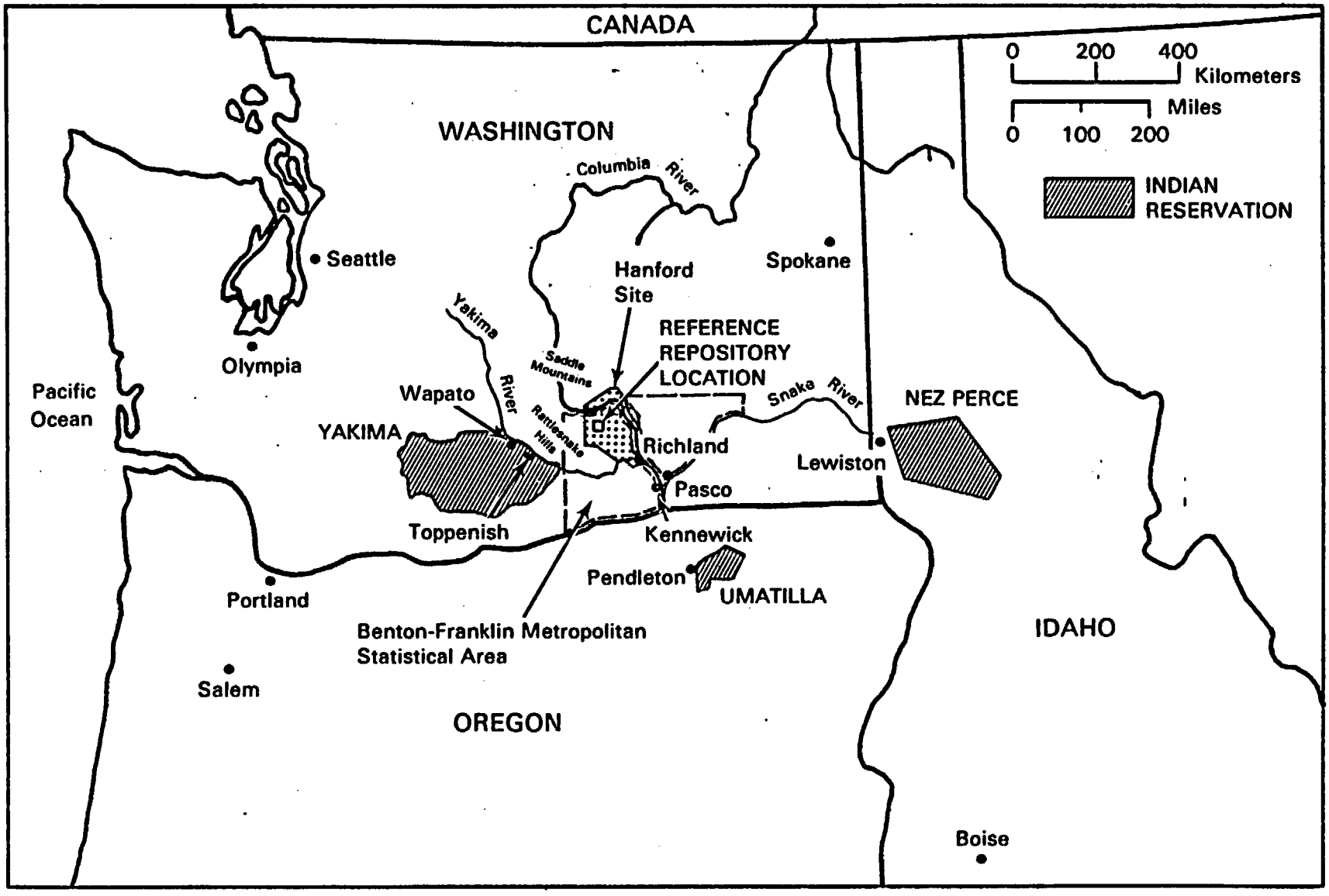

FIGURE 1. Location of the Benton-Franklin Metropolitan Statistical Area, and the Yakima Indian Nation, Umatilla, and Nez Perce Reservations.

Benton County, site of the potential repository, had a population of 104,000 in 1986, a decline from the 111,300 people in 1981 [Washington State Office of Financial Management (OFM) 1986]. The reasons for the population decrease are the 1981 stoppage of construction of the Washington Public Power Supply System nuclear reactors WNP-1 and WNP-4, and the completion of WNP-2. Construction of the projects from 1973 to 1981 resulted in rapid employment and population growth; termination and completion of construction had the reverse effect. The county economy remains heavily dependent on federal and contractor employment at the Hanford reservation. Recently, local efforts to diversify the economy by attracting other businesses, such as high-tech firms, has had some success. The county's principal cities are Richland and Kennewick.

Franklin County's 1986 population was 35,300, compared to its peak 1981 population of 35,900 (OFM 1986). It has a primarily agricultural economy, but Franklin County is intertwined economically and socially with Benton County since 1) some Franklin County residents are employed at Hanford or by businesses that rely on Hanford activities for support, and 2) Pasco is adjacent to Kennewick and within 10 miles of Richland. These cities are known as the "Tri-Cities."

The populations of Benton and Franklin Counties are predominantly white, with substantially lower proportions of Blacks, American Indians, and Asian Americans than the rest of the state. However, both counties have about double the statewide proportion of persons of Spanish origin.

Yakima County's economic base is agriculture, and much of the county is rural. Its population is relatively large [at 183,600 in 1986 (OFM 1986)], however, partly because the city of Yakima is a regional agricultural services center and several of the county's other cities are secondary agricultural centers. Average annual unemployment rates in Yakima County are consistently above the statewide rate.

Umatilla County, Oregon, and Nez Perce, Lewis, Clearwater, and Idaho Counties, Idaho, are primarily rural and agricultural, have generally lower

populations and population densities, and have higher proportions of American Indians than Benton or Franklin Counties. Unemployment rates are generally higher than in more urbanized Benton and Franklin Counties.

2.0 HISTORICAL OVERVIEW OF INTEGRATED MODELING IN REGIONAL ANALYSIS

Sections 2.0 and 3.0 present background material on the development history and general structure of ED models. Readers familiar with ED models can proceed directly to Section 4.0, Model Evaluation Criteria.

Since the 1960s, the basic techniques used in regional economic and demographic analysis have been developed and refined, because of an increased recognition of the interdependence of economic and demographic factors in regional analysis. Technological improvements, notably increased power and availability of computers, enhanced the development of more complex models for regional analysis.

The first regional models that combined economic and demographic components in one analytic system were the traditional Lowry Model and the Susquehanna River Basin Model, developed during the 1960s (Lowry 1964; Hamilton et al. 1969). Both of these models had enormous influence on subsequent socioeconomic modeling efforts. The Susquehanna River Basin Model, for instance, linked the economic and demographic components and used feedback loops between the two components. This model, in particular, influenced the structure of a regional forecasting model developed by the Tennessee Valley Authority, a series of economic-demographic models developed by Arizona and Utah, the MULTIREGION Model developed at the Oak Ridge National Laboratory, and the North Platte River Basin Model (Canter et al. 1985; Leistritz, Chase, and Murdock 1986).

All of these models linked the economic and demographic components through a submodel routine that simulated the operation of the labor market and provided for migration to and from the study area in response to labor market imbalances. This migration linkage was a key element in achieving the primary goal of ED models: consistency between economic (employment, income, etc.) and population projections. Many ED models were used as projection tools in state and regional economic planning, but early models did not address impacts below the county level.

As a result of the National Environmental Policy Act of 1969, interest in evaluating community-specific impacts of major resource development projects increased during the 1970s. However, ED models were limited as impact assessment tools. They 1) failed to include a number of important impacts, such as impacts on public services and fiscal balances; 2) generally provided projections only at the county or regional level, rather than for subcounty areas; and 3) often produced projections only at 5-year intervals. In response, a number of "second-generation" ED models were developed in the mid-1970s to rectify these deficiencies, such as the RED-1 and RED-2 models (Hertsgaard et al. 1978; Leistritz et al. 1979); the BREAM model (Mountain West Research Inc. 1978); the BOOM model (Ford 1976); the SEAM model (Stenehjem 1978); the HARC model (Cluett et al. 1977); and the SIMPACT model (Huston 1979). These models differed from the earlier ED models primarily in the number of impact categories and the degree of spatial and temporal disaggregation.

Most of the current generation of ED models have comparable structure and produce similar outputs. The next section describes this current generation.

3.0 OVERVIEW OF ED MODEL STRUCTURE

Although ED models differ substantially with respect to their data input requirements, computational procedures, forms of output, and other aspects, most are similar in overall structure and in the categories of impacts they address. The major components typically found in ED models are depicted in Figure 2. They usually include an economic module, a demographic module, and a module that reconciles projections of labor supply and demand (called the "ED interface" or "labor market" simulation module). In addition, many models include a subarea allocation module that distributes population changes from the regional or county level to individual towns and jurisdictions.

Some models also project changes in public services and facility requirements and impacts on the costs and revenues ("fiscal impacts") of various jurisdictions (e.g., counties, municipalities, school districts). These services and fiscal modules are essentially modified spreadsheets. Fiscal and services models that are flexible enough to accommodate a range of local conditions invariably impose heavy analytical demands on the model user. Evaluation of the available services and fiscal modules led to the conclusion that the preferred option for the BWIP is to develop services and fiscal models tailored to the needs of the Tri-Cities rather than use existing models.

The rest of Section 3.0 describes the essential elements of each ED module, without attempting to critique the approaches used. Sections 4.0 and 5.0 address theoretical issues.

3.1 ECONOMIC MODULE

Economic impact analysis has two fundamental ingredients: 1) an estimate of the outside stimuli that produce direct impacts, such as site characterization or development of a repository, and 2) a model of the regional economy that produces estimates of the indirect effects. Economic impact modules typically use economic base, input-output (I/O), or

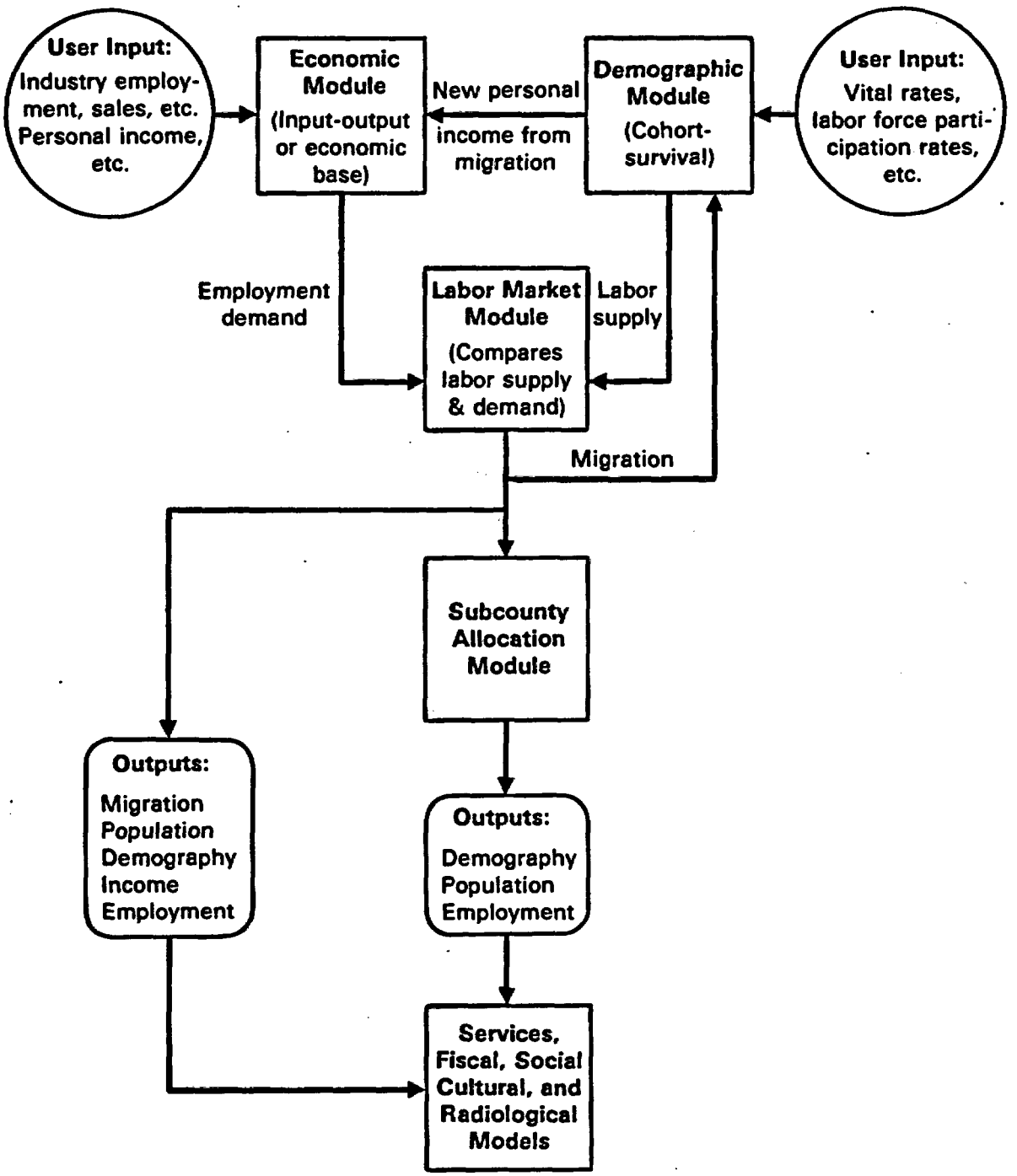

FIGURE 2. Generalized Diagram of ED Model Flow

econometric methods, alone or together. These methods vary in the industry detail presented, input data and analytical effort required, and underlying regional growth theory. Each method has desirable features, as well as drawbacks (discussed in Section 4.0). Thus, the choice of approach will depend on the nature of the problem as well as the resources available.[a] Typical outputs from this module include employment by industrial sector and personal income by type. These outputs may also include production value, investment, value added, occupational demand, consumer prices, factor prices, wages, and sales.

Data inputs required for the economic impact module vary among models. For model runs without the effects of the proposed project, (without-project runs), input data can include historical and projected employment, income, and/or sales by basic industrial sectors for the area under consideration. Most of this information is usually available through a variety of secondary sources, including publications of the Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), and Bureau of the Census. Some ED models require only "raw" secondary data, while others require that the model user estimate inputs from secondary data, such as how much of a sector's employment (using BEA data) is "basic" (employed to produce exported goods and services) versus "nonbasic" (employed to produce goods and services consumed locally). For with-project runs, data on project employment, wage payments, and local purchases of goods and services are often required.

3.2 DEMOGRAPHIC MODULE

Most demographic modules use cohort-survival or employment-population ratio methods to determine the size, and age and sex characteristics of the affected local population. Input data include the initial population, its age and sex structures, its distribution among county and subcounty areas, and projections of vital (birth and death) rates and labor force participation rates. Outputs of the demographic module include future population and labor force estimates, often by age and sex structure. Race

(a) Excellent summaries of these techniques are available in Bolton (1985), Richardson (1985); and Glickman (1977).

data are sometimes required as input, and some demographic modules can produce racial profiles if required for the project.

3.3 ECONOMIC-DEMOGRAPHIC INTERFACE (LABOR MARKET) MODULE

The ED interface module, used for both with- and without-project runs, is the primary driver of population change. It compares the available labor force from the demographic module to the employment requirements from the economic module, and "migrates" people into or out of the study area to achieve balance in the labor market. Some models can also handle nonemployment migration, such as that of retired and college-age persons. The age and sex structures of migrant populations are specified differently by all ED models.

The ED models do not address "anticipatory migration," a concern expressed in the comments on the Draft Environmental Assessment for the Hanford Site. This term refers to individuals who migrate to an area seeking employment, often in response to rumors or information that opportunities exist. If they are unsuccessful at securing employment, these individuals may remain in the area for some time, living on savings, unemployment insurance, or welfare, rather than moving away. In areas where anticipatory migration is expected to occur, the model user must typically make adjustments by changing assumptions outside the model. Models that provide for migration not associated with economic factors (such as retirement) can often be used to address anticipatory migration, but the model user must provide the estimates of migrants who remain in the area without taking jobs.

For the with-project scenario, the user must typically obtain estimates of 1) the proportion of new project-related jobs that will be filled by local residents, and 2) the various classes of project-related jobs, to provide demographic profiles of migrating workers and estimations of the potential for local recruitment (Leistritz and Murdock 1981).

3.4 RESIDENTIAL ALLOCATION MODULE

The residential allocation module is included in many modeling systems to distribute population changes from the regional or county level to individual jurisdictions (municipalities, school districts, etc.). Various approaches have been used to allocate in-migrants to subcounty jurisdictions, including gravity modeling techniques,(a) linear programming routines, and judgmental models. Gravity techniques have a long tradition of use in demography and regional economics and are widely used in ED models, but often do a poor job of explaining subarea population trends. Combinations of gravity techniques with judgmental factors (e.g., community attractiveness and housing availability) can improve the accuracy of subcounty allocation.

(a) Gravity modeling techniques are based on the assumption that in-migrants chose their residences based on a number of characteristics, including closeness to the work place, level and quality of urban services, and community attractiveness. These and other factors can be modeled to produce projections of the residential distribution of a group of in-migrants.

4.0 MODEL EVALUATION CRITERIA

Evaluation of a model involves comparing its procedures and outcomes to performance criteria developed by the prospective model user. This evaluation can then be compared to evaluations of alternative models.

Development of criteria is a critical step in model evaluation. A number of recent articles and reports have examined criteria for evaluating socioeconomic assessment models (Leistritz, Chase, and Murdock 1986; Canter, Atkinson, and Leistritz 1985; Winter 1986; ECOS Management Criteria Inc. 1982). Various criteria described in these references were reviewed in light of the particular needs of BWIP (for a defensible, state-of-the-practice model that will produce the appropriate information in a manner clearly understood by affected and interested parties) to produce eight criteria for evaluating models. These criteria are:

1. soundness of theoretical basis

2. relevance of model outputs to the BWIP information requirements

3. suitability of the model to the local economy, allowing for
   - validation
   - special populations
   - multiple projects
   - economies dominated by one sector

4. clarity of model documentation, including
   - a user's guide
   - consultation from model vendor
   - interactive capabilities
   - annotated source code

5. ease of changing model to correct deficiencies (adaptability)

6. ease of input data management

7. clarity and completeness of presentation of model results

8. availability and timing.

Each of these criteria is discussed below.

4.1 SOUNDNESS OF THEORETICAL BASIS

One of the most important attributes of defensible ED models is consistency with regional development theory. The main theoretical isssues for ED models are discussed below for each module.

4.1.1 ED Interface Module

The primary motivator for early ED model development was recognition that population and economic development are linked via migration. Although all ED models under consideration for BWIP reflect this aspect of growth theory in their ED interface modules, they differ in the way in which migration is specified. For example, some allow local unemployment rates to vary between upper and lower thresholds before migration is stimulated to achieve labor market balance, while others continually migrate workers and families in response to changes in employment demand without addressing unemployment rates at all.

Both approaches provide reasonably good long-run forecasts,[a] but are only partially consistent with short-run aspects of migration theory. The lack of good data to support better migration specifications is a problem for impact planning and management. One model vendor, Regional Economic Models Inc.(REMI), has recently made available a demographic and interface module that attempts to solve the data problem while using elements of migration theory.

4.1.2 Economic Module

As noted earlier, ED models use a variety of approaches to produce forecasts of employment, income, sales, and other economic variables.

(a) The threshold approach will generally produce long-range population forecasts at which the user-specified upper or lower bound unemployment rate will be maintained, depending primarily on the user's projected rate of growth in basic employment, vital rates, and labor force participation rates; thus, there is somewhat of an inherent tendency with forecasts to produce estimates that are too high or too low. On the other hand, continual migration does not address unemployment rates at all, but implies no change from the base-period value.

Economic base, input-output (I/O), and econometric techniques, or combinations of the three are used by all ED models. Economic base models are the simplest of the three. However, the underlying theory does not address many important issues, such as indirect export sales (which are not distinguished in theory from nonbasic activities). Widely accepted empirical methods to accurately quantify basic and nonbasic employment do not exist. Input-output models can provide excellent depictions of interindustry relations at a point in time, but their usefulness in forecasting economic change, particularly when structural change is an issue, is limited by their nondynamic nature.

The inability to identify changes in the economic stucture of a local economy, or to quantify changes in prices or wages (which are important factors in structural change and overall regional development), are major shortcomings for both the economic base and I/O approaches. Econometric methods can be more flexible since they typically allow for changes in prices and wages, and hence industrial structure. However, econometric analysis, which requires extensive data, is often limited by the short data series available for most small areas.

Another shortcoming of most ED models is not allowing enough time for the effects of economic stimuli to work through the economy. In most models, processes that are known to require several years, such as multiplier effects and achievement of equilibrium in the labor market, are assumed to occur immediately (within the year of the outside change). A few models allow lags to occur, which can improve the realism and accuracy of forecasts.

4.1.3 Demographic Module

Most demographic modules use cohort-survival methods, which are well accepted in theory. However, implementation of the theory differs among models. These differences may include sources of historical and projected vital rate data, assumptions concerning labor force participation rates and skills of the local population, and age, sex, and household characteristics of migrating workers. Each of these factors must be critically evaluated by the model user.

4.1.4 Subarea Allocation Module

Allocation of population and employment to areas below the county level is the most difficult issue addressed by ED models because of the myriad factors influencing residential location decisions, the high degree of variability from place to place, the lack of locally applicable data, and the low explanatory power of existing location models, such as gravity models. No ED models do a truly satisfactory job of subarea allocation, yet given the importance of accurate community-based forecasts to sound impact management planning, this task is often critical. Given the current state of the practice, subarea allocation is very approximate.

One approach commonly used is to identify large basic projects planned for the future and estimate the residential location of their workers based on gravity models and/or judgment, and to assume that nonbasic employment will follow the location of basic-worker residence. An analytical approach that is simpler, but theoretically less satisfactory, is to assume that historical residential location trends will continue into the future and that employment will follow the projected population trend. Combinations of the two approaches are likely to be most accurate; time-series analysis of local population and basic/nonbasic job locations, including those of the BWIP work force, should be used to evaluate the subarea allocation method used.

4.2 RELEVANCE TO BWIP INFORMATION REQUIREMENTS

Section 113(a) of the Nuclear Waste Policy Act of 1982 (42 U.S.C. §§10101 et seq.) requires the U.S. Department of Energy (DOE) to conduct site characterization in a manner that minimizes, to the maximum extent practicable, any significant adverse environmental impacts identified either in the Environmental Assessments (EA) for the three candidate sites, or from public commments at hearings held in conjunction with DOE's nomination of three sites or at hearings to be held in conjunction with the draft Site Characterization Plan. To that end, DOE is developing Socioeconomic Monitoring and Mitigation Plans (SMMPs); an SMMP working draft has already been prepared for the Hanford Site (DOE 1986). The draft

SMMP identifies economic and demographic data needs for BWIP. One use of the ED model(s) selected for BWIP is to provide a vehicle for linking site characterization activities to economic and demographic changes. This will allow impact management planning to be performed on a sound informational basis. The categories of information required are

Demographic - Changes in the size, composition, and geographic distribution of the Tri-Cities area (Benton and Franklin Counties) population will be assessed. The model(s) should provide projections of age/sex structures, migration, and population by subarea (such as county, city, and special district).

Economic - Economic information requirements include employment, unemployment, wages, personal income, business activity and diversity (economic structure), and consumer prices. Changes in these economic indicators can be due to either 1) direct project employment, or 2) general economic growth stimulated by site characterization. Therefore, the ED model(s) selected should be capable of quantifying economic linkages, such as that between basic economic activity and changes in trade, service, and other nonbasic economic sectors. The analysis of changes in economic structure should, at a minimum, be at the 2-digit Standard Industrial Classification (SIC)(a) level of detail to adequately track economic structural change. The model(s) should also identify the geographic location of changes in direct and indirect employment. Since local supply and demand for specific occupations are associated with in-migration, it would also be desirable to simulate changes in local occupational structure.

4.3 SUITABILITY TO LOCAL ECONOMY

A model's suitability for a local economy rests primarily on the user's ability to validate it. Validation, as used here, means performing model runs that replicate historical data and produce reasonable

(a) SIC codes are used in many standard economic data series to classify businesses according to their product. The more digits in the SIC code, the more specific is the description of the activity.

simulations of the effects of hypothetical economic stimuli.[a] There may also be special local conditions or projection needs that affect a model's suitability. In the case of the Tri-Cities, the model must accurately model economic downturns as well as growth, handle multiple projects simultaneously, address special populations, and simulate economies documented by one sector. These issues are discussed below.

4.3.1 Model Validation

Although the ability to reproduce historical data is no guarantee that a model will perform well in forecasting future conditions, historical-data replication is generally accepted as a good indicator of likely future success. Put another way, models that fail to replicate historical data are unlikely to forecast well. Validation involves choosing a period for which the model's input (actual) data are available, and another period immediately thereafter for which values for both the input and forecast predicted data are known. Model runs are then made using the second period as the forecast period, and the model predictions are then compared to actual values to evaluate the accuracy of the model.

In some cases, models that can adequately replicate historical data still do not produce realistic simulations of impacts. Therefore, validation also includes performing a variety of test runs for hypothetical actions, and examining the magnitude, duration, pattern over time, and other characteristics of the resulting impact simulation. This activity requires careful judgment by the analyst to determine the "reasonableness" of the simulation.

4.3.2 Modeling Economic Downturns

Although the recent history of the Tri-Cities is one of economic decline from 1981 to about 1985 and stabilization during 1986, some growth will occur in the future with or without site characterization. Whether growth or contraction occurs depends on several factors, including federal

(a) Validation is defined in a number of ways. In some cases it includes an evaluation of the model's consistency with theory. A narrow definition is used here, including only the model's ability to reproduce historical data and produce reasonable simulations. Consistency with theory issues are separately addressed in Section 4.1.

actions at the Hanford Site, the success of local economic development initiatives, and world and national events affecting agriculture. Alternatively, depending on the assumptions used, further economic contraction could occur. Thus, the model should be validated for periods of both economic decline (1981 to about 1985) and growth (before 1981).

However, model validation success for the Tri-Cities may depend more upon the model's ability to track data for economic downturns than upturns. Most ED models were formulated to address boom-town issues in rural areas, for which in-migration and economic growth were key issues; hence, they perform reasonably well when applied to growth situations. Although most economic and demographic modules run as well "in reverse," the factors affecting in-migration and out-migration may not be symmetric (i.e., laid-off workers may remain in the area for a long time before accepting positions elsewhere, while new jobs create population increases very quickly). Thus, the ED interface module, and hence the model as a whole, may not perform as well for declining employment as for growth.

Past uses of the model under scrutiny can often provide a good indicator of its likely performance in validation. Models that have been successfully applied to economies similar in size, structure, and growth history to the Tri-Cities are likely to also work well for the Tri-Cities.

4.3.3 Special Populations

Special populations are those groups, comprising a significant share of the local population, that have different demographic and/or migration characteristics than the rest of the population. Examples are college students and military personnel, who typically migrate out of the area upon graduation or completion of service, and retirees and other persons with substantial nonemployment income, whose residential location does not depend on employment opportunities. In the Tri-Cities, construction workers are considered a special population; it is believed many are commuting long distances to work rather than moving their families from the Tri-Cities, and are sending a large proportion of their paychecks home to the Tri-Cities. For BWIP, local college-age students in the Tri-Cities and American Indians in the other study areas are also of primary concern to

accurate ED modeling. The chosen model(s) should be able to address the demographic and migration characteristics of these groups.

4.3.4 Multiple Projects

One of the most important aspects of the Tri-Cities' economic and demographic system that will have to be taken into account is the number of major projects that may or may not take place in the future, or for which the schedules and/or levels of activity are difficult to predict. These projects include closure or restart of the N-Reactor and/or new plutonium production reactor development, and implications regarding other elements of the Nuclear Production Mission such as the PUREX reprocessing plant; restart of the WNP-1 project at Hanford; future activities at the Hanford Defense Waste management project; conversion of the fast-flux plant to electrical production; and additional currently unanticipated long-term government projects.

The various possible combinations of projects, their timing, and their levels of activity make forecasting Hanford employment, as it relates to national political decisions, somewhat speculative. Thus, a "scenario" approach to without-project analysis will likely be used. Successful impact assessment for BWIP will likely rest on the ability to create a number of credible baseline scenarios that span the range of likely future federal projects, and isolate the effects of site characterization and potential repository development. Thus, the ability of the model to accommodate multiple projects is important.

4.3.5 One-Sector Dominated Economy

Another factor to be considered in model evaluation is the dominance of employment by the federal government and its contractors in the Tri-Cities; accurate estimates and forecasts of the linkages of federal expenditures on goods, services, and wages to other local sectors is very important. Data on Tri-Cities employment and income by industry and on interindustry linkages are often supressed (to avoid disclosure of information that is proprietory to private firms) by the Bureau of the Census, Bureau of Economic Analysis (BEA), and Bureau of Labor Statistics (BLS), which are standard sources of much of the economic and demographic data used by ED models. Therefore, the model(s) selected should be

applicable to economies dominated by a few industries, such as in the Tri-Cities. Since modeling small regions is often difficult because of poor or unavailable data, the model(s) selected should provide the user with a means to handle data gaps[a]

4.4 CLARITY OF DOCUMENTATION

Quality of documentation is extremely important to the evaluation of ED models for BWIP because of 1) the difficulty of certifying ED models in the usual manner called for by Quality Assurance procedures,[b] and 2) the high likelihood that changes in the model source code will be necessary as validation proceeds to improve the model's forecasting and simulation capabilities. "Documentation quality" as used here includes 1) the clarity of the user's guide, 2) the availability of consultation from the model vendor, 3) the interactive capabilities, or "friendliness," of run control routines needed to direct the program to perform the appropriate model runs, and 4) the availability of a hard-copy annotated source code to facilitate reprogramming.

4.5 EASE OF CHANGING MODEL TO CORRECT DEFICIENCIES (ADAPTABILITY)

Because no model exactly matches the needs of the user, a very important question is "how easy is it to modify the model to match the user's needs?" Model modification may take the form of adding entirely new modules (such as a subarea allocation module), altering the flow of existing modules, changing model parameters (such as intersectoral purchase coefficients), or creating output files for other uses (such as graphics). The adaptability of the program depends on several factors, including the

(a) Such data gaps may be caused by disclosure limitations (for example, BEA employment data) and lack of data collection (for example, vital rate data specific to American Indians may not be available).

(b) For most engineering and many environmental models, Quality Assurance includes creating a set of input data, operating on that set with the model, and tracking each calculation made by the model to ensure that the model produces the intended mathematical results. For ED models, which often include well over 1,000 equations and similarly complex source codes, use of this method is clearly not possible. Thus, quality assurance most often involves a less rigorous examination of the source code and documentation, as well as test-running the model to ensure that its simulations appear reasonable.

ability of the user to purchase the source code, comprehend it sufficiently to make required changes, and perform appropriate reprogramming.

4.6 EASE OF INPUT DATA MANAGEMENT

ED models place a range of input data demands on the user. Some require only a small amount of readily available data, while others require large volumes of data, some of which must be interpreted and/or recalculated by the user to match the needs of the program. In general, the greater the level of geographic, industrial, demographic, fiscal, and other detail provided in a model's output, the greater the volume of input data required. However, some models have particularly well-designed input procedures, and/or have internal data bases that provide some relief from otherwise demanding input requirements.

Furthermore, entering data can be easy or difficult; screen prompts clearly identifying the data requested by the program, and screen or hard-copy input-file summaries are most useful. All else being equal, it is desirable to minimize input demands since ED programs are by nature complex enough.

Given the probable requirement for a scenario approach to modeling the Tri-Cities economic and demographic structure, and hence the need for multiple without-project model runs, the ability of the model to manage input files becomes important. A method for clearly describing the assumptions used in the files should be available to the user, and the program should allow for a number of user-specified options and default values that are clearly presented in each run's output.

4.7 CLARITY OF PRESENTATION OF RESULTS

Because the primary reason for using an ED model is to produce numerous assumption-driven and consistent forecasts of economic and demographic variables, the output from the model can be voluminous. Clarity of presentation therefore becomes important. Output tables should provide a recitation of the basic assumptions and control parameters used in the run, and should be well organized. The model should provide, as

specified by the user, both summary and detail tables for without-project, with-project, and impact projections.

For many applications, the ability of the model program to produce graphics is of importance. For the BWIP, typical uses will likely include time graphs, bar and pie charts, and maps.

4.8. AVAILABILITY AND TIMING

An operational consideration important to the BWIP is whether a working model can be made available for use at the times required by the project schedule. As noted in the introduction, an operational model should be in place by the beginning of FY 1988 to perform analyses of monitoring data.

5.0 MODELS SELECTED FOR COMPARATIVE EVALUATION

From a list of 10 ED models, three were chosen for detailed evaluation. The criteria used to select the three models were 1) recent history of successful use (many models, designed for the energy-development period of the late 1970s and early 1980s, have not been updated or used in recent years), 2) availability of documentation that meets Quality Assurance requirements, 3) ability to produce annual projections at least to the county level, and 4) availability of their source code. Table 1 presents a list of all the models considered and the reasons for not considering some models further. The models selected for the evaluation are: 1) Mountain West Research-Southwest's Planning and Assessment System (PAS) Model, 2) Regional Economic Models Inc.'s (REMI) FS-53 model, and 3) the Socioeconomic Analysis of Repository Siting Model (SEARS).

In addition to those three models, a "hybrid" model was considered in the evaluation. Such a model would combine the strongest elements of each of the three candidate models (see Section 6.1 for additional discussion of the hybrid model). Descriptions of the three finalist models are presented below, focusing on general information about the models and information relevant to each of the criteria discussed previously. Additional information is presented in the Appendix.

The models were evaluated unevenly. The PAS and REMI evaluations were based on previous uses of the models and/or their precursors, scrutiny of the models' documentation, review of journal and academic literature describing the models, and/or discussions with principals of the vendor firms. The SEARS model, however, was subjected to a thorough peer review by a panel of experts as part of the Office of Nuclear Waste Isolation (ONWI) program. The panel's comments are summarized in Cluett, et al. (1986). The SEARS evaluation was based on SEARS precursor models [the Texas Assessment and Modeling System (TAMS)], examination of SEARS documentation, and the comments of the peer review panel. Thus, the SEARS model has been the subject of more intensive--and critical--review than

TABLE 1. Initial List of Models Evaluated for Use in the BWIP

Model	Comment
Air Force System Evaluation Model (URS-Berger 1983)	Not extensively used
BOOM-1 (Ford 1976)	Not extensively used
PAS (Mountain West Research-Southwest, Inc. 1983)	Selected for final evaluation
COALTOWN (Bender, Temple, and Parcels 1980)	Not extensively used, inadequate documentation
NEDAM (Leistritz et al. 1982)	Precursor of SEARS
REMI (Treyz and Stevens 1985)	Selected for final evaluation
SEAM (Stenehjem 1978)[a]	Not recently used
SEARS (Texas Agricultural Experiment Station 1984)	Selected for final evaluation
UPED 79 (Weaver et al. 1980)	Not extensively used, inadequate documentation
Western Research (Western Research Corporation, no date)	Inadequate documentation

either PAS or REMI models.[a] In developing the model evaluation ratings presented later in this paper, an attempt was made to compensate for the greater level of review of the SEARS model in order to achieve a balanced and accurate comparative review of the three models.

It is also important to note that the SEARS model is being revised in response to the panel's review comments; the model should be improved once revisions are completed in FY 1988. Nonetheless, to achieve the goals of this task (Section 1.2), model development must be initiated during FY 1987. The current SEARS model was included in the evaluation.

(a) Although both PAS and REMI models are the subject of more review in theoretical and academic literature than SEARS or its precursors, those reviews are generally more descriptive, less exhaustive, and less critical than the SEARS peer panel review.

5.1 MOUNTAIN WEST RESEARCH-SOUTHWEST INC[a] PLANNING AND ASSESSMENT SYSTEM (PAS) DESCRIPTION

Of the models evaluated, the Planning and Assessment System (PAS) and its antecedents have been in use the longest. The models have been used almost exclusively in the Western states. However, the PAS model has not been formally validated, although its general approach has undergone extensive scrutiny in technical publications and forums. The PAS has strengths in its level of demographic and geographic (i.e., subcounty) detail, but is relatively weak in its expression of the economic aspects of regional development theory.

The antecedent of PAS, the Bureau of Reclamation Economic Assessment Model (BREAM), was originally developed for the U.S. Bureau of Reclamation to assist the agency in preparing socioeconomic impact assessments for water projects in the western states (Leistritz and Murdock 1981; Canter, Atkinson, and Leistritz 1985; Mountain West Research Inc. 1978). Later, Mountain West Research expanded the model for use in socioeconomic impact assessment studies and tested it throughout the Rocky Mountain region.

PAS consists of three modules linked together in a data base management and simulation system. The first major component, the Basic Activity System (BAS), is a data base manager that provides a convenient method of tracing the critical assumptions behind a given set of projections. BAS is particularly useful when several large projects happen simultaneously in a study area; it stores direct employment, income, work force demographic and residential characteristics, and local purchases of materials and supplies for each project, all of which must be determined by the user. BAS can also store data on a single basic sector, such as agriculture. This stored information is relayed to the projection modules of PAS.

The second major component, the County Projection Module (CPM), is further divided into three modules: 1) a demographic submodel, 2) an economic submodel, and 3) a labor market (or ED interface) submodel.

(a) Phoenix Gateway Center, 432 N. 44th Street, Suite 400, Phoenix, AZ 85008.

The demographic module uses a cohort-survival process with user-supplied age, sex, and vital rate information to simulate the impacts of births, deaths, and nonemployment-related migration on county population. Several options are available for projecting vital rate trends, including converging local vital rates and labor force participation rates to projected national rates. PAS can handle special populations, including retired persons, students, and construction workers. Mountain West dropped the provision for handling Indian reservations, which was present in BREAM, because of the lack of good demographic data. Labor force participation rates supplied by the user (and that can be trended toward projected national rates) are used to estimate available work force. These rates are not sensitive to changes in labor demand, however.

The economic module determines total employment by major industry sector (1-digit SIC code) based on the level of basic activity projected by the model user for the county. Nonbasic employment is determined through a set of coefficients that relate nonbasic employment in a given sector to total personal income within the county and, for trade center counties, to personal income in the trade area. The economic module combines the advantages of the income multiplier method with market area concepts, thus allowing the geographical distribution of secondary economic effects to be evaluated. However, PAS's economic module is not well developed in its expression of intermediate industry linkages, provides only the 1-digit SIC level of detail, does not address price or wage changes, and has no occupational detail. In addition, it permits structural change in the economy only through user-defined changes in interindustry purchases compiled by the BAS. The model uses only annual employment averages, which may understate the consequences of seasonal peaks.

The labor market module evaluates the consistency between county-level labor supply and demand and estimates the amount of employment-related migration necessary to bring labor supply and demand into equilibrium. Demographic characteristics of migrants depend upon the economic sector in which they are employed; Social Security work-sample data from the mid-1970s are used, but Mountain West will re-evaluate this data base during the next year. The number of migrants (by age and sex) is

added to the estimated local population from the demographic module to obtain an estimated annual population and labor force for the county. "Migration-triggering unemployment bounds" are specified by the user; if the county's estimated unemployment rate during any year falls outside the upper and lower bounds, migration is stimulated until unemployment falls between the bounds. This specification is somewhat unrealistic since migration is likely to be correlated with factors such as unemployment by occupation, local labor force participation rates, and local wages, and is unlikely to occur in sudden leaps as the PAS model implies.

These submodels produce county-level population, employment, and income projections for any set or subset of the basic activities. These projections are organized by,

- components of population change
- components of employment-related migration
- components of nonlocal construction workforce
- population by age and gender
- employment-related migration by age and gender
- school population by age
- deaths by age and gender
- births by age of mother
- nonlocal population by age and gender
- total employment by sector
- basic employment by sector
- nonbasic employment by sector
- employment by type
- labor income by type
- personal income by component

The third major component, the Subcounty Allocation Module (SAM), disaggregates the outputs of the CPM and assigns economic, demographic, and housing estimates to subcounty jurisdictions. The user specifies the method of allocating employment and population to subareas (BREAM used a gravity model, which was judged to not predict well and so was dropped when PAS was written).

The SAM also provides numerous tables by user-defined jurisdictions, including estimates of population change, employment migration, nonlocal construction workforce, employment by both place of residence and place of work, labor income, components of housing stock, and housing demand by unit type.

PAS has been designed for relative ease in transferring from one site to another. Input data demands are heavy, but PAS relies primarily on secondary data from such sources as the Bureau of the Census, BEA, and various state agencies. The most difficult data-input issue for the user is determining how much of a 1-digit economic sector's employment has been in the past, and how much will be over the projection period, for export goods and services. As noted earlier, no widely accepted techniques exist to accurately estimate the basic/nonbasic structure; the best method for estimating is to use survey data such as those gathered through I/O-type studies. Thus, linkage of PAS with I/O or other more sophisticated economic modules is advantageous. PAS allows the user to alter numerous variables and parameters, including the level of basic activity, fertility and mortality rates, place of residence of project-related workers, spending patterns of workers, and the allocation factors for nonproject population growth.

5.2 REGIONAL ECONOMIC MODELS INC. (REMI)[a] FORECASTING AND SIMULATION (FS) MODEL DESCRIPTION

While the PAS model excells in its specification of demographic characteristics and subcounty allocations, the Forecasting and Simulation (FS) models produced by REMI have extremely well-developed economic modules. REMI has also recently made available a demographic and labor market module that is unique in its attempt, by using job search theory, to solve the "lumpy" migration patterns trend of the PAS-type approach. However, the FS demographic model has not yet been used for any studies, and FS models have no subcounty capabilities. This description focuses on the REMI FS-53 model, which uses the 2-digit SIC level of detail. REMI also produces a 1-digit SIC model, and a 500-sector I/O model that can be

(a) 306 Lincoln Avenue, Amherst, MA 01002.

linked with either the 1- or 2-digit models to provide a high level of industrial detail.

The FS models are characterized by their focus on the relationships among industry sectors and their use of variable I/O and other coefficients, which help solve the main shortcoming of I/O models in regional analysis: their inability to express structural change. The models are dynamic in that 1) structural change can occur over time because of changes in prices, wages, and technological advances, and 2) lags in the economic system response to outside stimuli are included. For a more complete description of the FS models' structures, see Treyz and Stevens (1985).

The I/O model underlying the FS-53 model is based on a matrix of U.S. technical coefficients provided by the BEA, which is adjusted by the model to reflect the local economy (it is possible that this I/O table could be adjusted to use the existing Washington I/O model). Adjusting from the national I/O table to a state or county level is accomplished via the "Regional Purchase Coefficients" (RPC) method, in which the share of purchases of goods by each industry from within the area is estimated for each 2-digit (SIC code) sector, based on an econometric analysis of national shipments data. RPCs are determined within the model and can change over time in response to outside economic changes, such as government policy shifts or project developments.

The RPC method for calibrating local I/O coefficients from national I/O tables has only recently been developed, and has not been extensively validated. However, RPC is more theoretically grounded than the traditional methods of calibration (the "Location Quotient" and "Supply-Demand Ratio" methods), partly because it does not ignore "cross-hauling,"[a] a failure of previous techniques. The RPC method was tested by REMI for the State of Washington by using survey-based I/O coefficients as the benchmark data, with results that were generally, though not uniformly, good. REMI has also compared the performance of the RPC, Location Quotient, and Supply-Demand Ratio calibration methods by using

(a) Cross-hauling is the trading of commodities between two areas that produce similar commodities.

shipment data from the Census of Transportation as the benchmark data. Although the Census of Transportation data are also somewhat limited as measures of actual inter-regional flows, this method of testing performance may have advantages over methods using existing I/O tables, because I/O coefficients themselves are often estimates. In this comparison, the RPC method outperformed the other methods over the data sample (according to research by Stevens, Treyz, and Lahr of the Regional Science Institute in Peace Dale, Rhode Island). However, more testing must be done before a clear judgment can be made.

The most distinctive feature of the FS models is their use of wage and price changes to influence changes in I/O coefficients and export sales over time (either annual or quarterly models are available). Economic stimuli such as a development project can affect wages both in the occupations directly affected and throughout the local economy. Wage changes can then affect the amount of labor, energy, and capital used by firms, as well as their total production costs. Changes in production costs can in turn affect not only the area's sales of export goods, but the RPCs that determine the economy's structure.

The equations specifying the responsiveness of wages, prices, and export volume to economic stimuli are estimated econometrically by REMI, based primarily on national data, since local time-series data usually do not adequately support econometric analysis. Thus, a few critical assumptions underlie the use of the FS methodology for local economies. First, production functions[a] in manufacturing industries are assumed to be of the same form across the United States (of the Cobb-Douglas form with constant returns to scale,[b] resulting in elasticities of factor

(a) "Production functions" are mathematical representations of industrial processes transforming raw materials into finished goods and services.
(b) "Production functions" are extremely difficult to specify econometrically. The Cobb-Douglas form is often used in empirical studies since 1) it is often easiest to estimate, 2) elasticities of factor substitution of about one are often considered reasonable, and 3) other forms that can be estimated often have their own undesirable assumptions.

substitution[a] equal to one for all areas and industries. Second, wage elasticities[b] are the same across the United States for each occupation. Third, price elasticities[c] of demand for exported goods are the same across the country.

While these elasticity restrictions may not apply for all areas, they do permit the FS models to avoid local data inadequacies. In cases where local values are known to differ from national values, changes can be made in model parameters.

. The FS-53 is the only model considered for BWIP that can be purchased in quarterly form, which may be useful if seasonal employment peaks exist. It also has a well-developed system of cause and effect lags so that, unlike other models, effects that require time to be realized are not assumed to occur almost immediately.

Another unique feature of the FS-53 model is its inclusion of 94 occupations, each with its own (nationally estimated) wage response to local supply-demand conditions. Since site characterization will require specific occupations, and since the Tri-Cities are saturated with some occupations, the FS-53 model may be well suited for BWIP because it can capture this local condition.

The FS-53 labor market module, which is just being completed, uses econometric analysis of national cross-section data on migration. The equation estimated for the analysis "migrates" workers in and out of the study area according to how study area wages and employment opportunities compare to national wages and employment opportunities, and uses cohort-survival techniques for demographic detail. While this formulation removes the "lumpiness" of migration inherent in the traditional approach (such as that used by PAS), there may be problems with the ability of the model to

(a) "Elasticity of factor substitution" is the ratio of formulation; for example, the percent change of the quantity of raw materials over labor, divided by the price of raw materials over labor. For more information, see Silberberg (1978).
(b) "Wage elasticity" is the ratio of percent change in the amount of labor used divided by the percent change in the wages paid to labor.
(c) "Price elasticity" is the ratio of percent change in the quantity of a good or service sold, divided by the percent change in the price of that good or service.

make forecasts of local migrations based on econometric analysis of national data, and documentation is incomplete. Further testing and better documentation are required before the approach can be fully evaluated.

The FS-53 model has some shortcomings for BWIP. It does not operate at subcounty levels, and it does not produce estimates of unemployment rates. These items are often considered standard economic indicators. As noted above, the demographic and labor market module has not been field tested and requires further evaluation. These shortcomings can be corrected at a reasonable cost.

The FS models were used solely in the more industrialized eastern and midwestern sections of the United States during the models' first few years of development. Recently they have also been used in the West. They have been used to evaluate the effects of both economic growth-inducing actions and growth-reduction actions, such as plant closings and environmental legislation. The only reported validation run of an FS model was done for Massachusetts, and the model produced highly accurate forecasts of economic conditions (Lanzillo et al. 1985). Given the models' success in more complex economies, it is likely that FS-53 can be successfully calibrated to the Tri-Cities area.

FS models place modest input-data demands on the user, since REMI estimates all structural equations. The data input requirements are 1) national GNP data (for historical runs) and projections (for forecasts), which are readily available from DRI or other forecasting services, 2) employment, wage payments, and capital purchases by vendor SIC code for with-project runs, and (3) various run-control options selected by the user. A historical data base covering a variety of economic variables is also available from REMI, which, alone or in conjunction with other information, may be used to improve model specification or provide needed data for validation runs. Documentation quality and file management capabilities are excellent. The model is written in FORTRAN, a relatively easy language to revise. The user can specify about 50 types of output tables of varying degrees of detail.

5.3 SOCIOECONOMIC ANALYSIS OF REPOSITORY SITING (SEARS)[a] DESCRIPTION

The SEARS model, which is based on the TAMS model developed in 1979 for Texas, is being revised in response to extensive peer-review comments. Some of the more significant comments made by the panel (Cluett et al. 1986) are included in this section. The model revisions, which are substantial, should be completed during FY 1988. Until the revised SEARS model is available, it will be difficult to compare it with other models. However, the revisions will be closely monitored and the completed model will be considered for use in BWIP.

As currently formulated, the demographic and ED interface modules resemble the corresponding PAS modules; however, numerous differences exist, including subcounty allocation before the ED interface module is used. An I/O-based economic module, which includes 27 economic sectors (combinations of 1- and 2-digit SIC code industries), is used. Each module is briefly described below.

The demographic module uses standard cohort-survival techniques to produce 75 age cohorts by sex and race (white and nonwhite). Statewide birth and death rates are suggested, although the user can choose county-specific rates. These rates can be modeled to parallel national rate forecasts, but evidently cannot be converged with them, as in PAS. "Labor force availability rates" are applied to each cohort, instead of the more common "labor force participation rates," but the meaning of "availability" is unclear. The subcounty allocation program assigns populations to cities (but not to rural or subcity areas) according to their historical share of total population. Unfortunately, local age, sex, and race data from the Census are not used to produce more realistic estimates of age, sex, and race structures by city.

The ED interface module compares labor supply (from the demographic module) with labor demand (from the economic module) by city, and migrates workers and families as necessary to achieve labor market balance. Using a city base for migration appears quite different from the PAS method and the

(a) Department of Rural Sociology, Texas Agricultural Experiment Station, College Station, Texas. Model developed under contract to Battelle Memorial Institute/Battelle Project Management Division, Columbus, Ohio.

documentation for SEARS does not clearly define the implications of this difference. The SEARS procedure seems inappropriate, since one would expect migration to occur as a result of imbalances in labor market areas as a whole rather than subareas. The data used to profile migrants' demographic characteristics are also somewhat weak, since no distinction is made between out-migrants and in-migrants; this, however, is a common problem for ED models. For with-project model runs, a gravity model similar to that used by PAS is used, including several options so the user can specify model parameters or directly allocate project workers to cities. Indirect in-migrants are allocated to cities according to historical population shares.

The I/O-based economic submodel defines 27 sectors. Although the I/O approach may be superior to the market area/basic-nonbasic multiplier method used by PAS, the input requirements are extraordinarily heavy. In addition, the main benefit of I/O models--sectoral detail--is not taken advantage of because of the low number of included sectors. The I/O coefficients are held constant throughout the forecast period; price, wage, or structural changes cannot occur over time. Jobs are allocated to cities according to the historical share of population, which is subject to considerable error.

Input data requirements for SEARS are heavy, and the user is required to provide not only readily available secondary data, such as demographic characteristics, but data that are difficult to derive, such as sales to final users for each of 27 economic sectors.

Model documentation is extensive, including the source code. However, given the heavy input demands placed on the user, reorganizing and editing would greatly improve its usefulness. The source code is written in APL, which is not commonly used and creates hardware support problems for BWIP. Adapting SEARS to the Tri-Cities would require extensive source

code modification. The time required to complete model and source code revisions to suit the Tri-Cities and other affected area economies is a disadvantage since these tasks could probably not be completed until FY 89.

6.0 EVALUATION OF ALTERNATIVE MODELS

6.1 EVALUATION METHODOLOGY

The three candidate models, PAS, FS-53, and SEARS, were evaluated by comparing them to the criteria discussed in Section 4.0. This evaluation was difficult in light of the ongoing modifications to SEARS. However, because BWIP needs modeling capabilities before the SEARS revisions are completed, it was decided to proceed with developing a model to support the overall socioeconomic program. This strategy will make available a longer period for development of a sound model than would be available if model selection were to be delayed until SEARS revisions are completed. This longer model development period is desirable given the goals of the BWIP socioeconomic program (Section 1.2).

A traditional "weighting-and-rating" procedure was used to rate the models. This method involves 1) identifying criteria (as in Section 4.0), 2) assigning relative weights to those criteria so that the most critical criteria exert the greatest influence, 3) rating each model against each criterion, 4) multiplying the ratings by the respective weights and summing the products for each model, and 5) comparing the total scores for each model.

Each criterion was given a weight in the evaluation, based on judgment of its importance relative to other criteria.[a] Each module was rated between 1 and 5 points for each criterion, the best model receiving 5 points (except for the economic module, which was judged to be the most important and was therefore accorded a 10-point maximum). By multiplying the weight of each criterion by the points assigned to each of the three candidate models and summing the resulting scores, a numerical rating was derived. The results are shown in Table 2; the rationale for the ratings is summarized in the Appendix.

(a) No guidance on appropriate weighting is available in the technical literature regarding ED model selection. This lack of general guidance is not surprising, since the appropriate weights will vary according to the regulatory and legal environment, uses of the model, and other factors.

TABLE 2. Summary of ED Model Ratings (see Appendix for Details)

Criterion	Weights	Ratings															
		PAS Model				FS-53 Model				SEARS Model				HYBRID Model			
		EM[a]	DM	LMM	SAM	EM	DM	LMM	SAM	EM	DM	LMM	SAM	EM	DM	LMM	SAM
Soundness of theoretical basis	0.20	4	5	5	5	10	3	3	0	6	5	4	4	10	5	5	5
Relevance to BWIP information requirements	0.15	4	4	5	5	10	3	3	0	7	5	4	4	10	4	5	5
Suitability to local economy	0.15	5	5	5	5	10	4	4	0	7	5	5	5	10	5	5	5
Clarity of documentation	0.10			4				5				4				3	
Ease of correcting deficiencies	0.20			4				5				3				5	
Ease of data input	0.05			3				5				2				3	
Clarity of presentation	0.05			5				5				5				5	
Availability and timing	0.10			4				5				4				4	
TOTAL SCORE[a]	1.0			19.5				20.8				18.85				22.85	

(a) Key:

EM - Economic Module
DM - Demographic Module
LMM - Labor Market (Interface) Module
SAM - Subcounty Allocation Module

(b) Total scores were derived by multiplying the ratings by the weights and summing. For criteria where only one rating was assigned for all modules, the rating was multiplied by five to ensure consistency with criteria in which ratings were assigned to each module.

Table 2 indicates that of the three stand-alone models, FS-53 is rated highest for use in BWIP, followed by the PAS and SEARS models. The scores for the three models are close, and are sensitive to changes in the weighting of criteria. For example, a sufficiently large (yet potential) reduction in the weight assigned to the first criterion, or a reduction in the importance assigned to economic modules in general, could change the order of the resulting scores.

Uncertainty regarding the actual performance of the models or their components also reduces the confidence that can be placed in the resulting scores. The higher rating of the FS-53 model is partly a function of the scores awarded its demographic and labor market modules; as noted in Section 5.2, these modules must be tested more before ratings can be more confidently assigned (the assigned scores are, therefore, conservative). Furthermore, the SEARS ratings could change once scheduled revisions are completed in FY 1988.

To address the uncertainty regarding the FS demographic and labor market modules and the ongoing modifications to SEARS, and to provide for subarea allocation model options, a fourth option was considered: a combination model that would take advantage of the strengths of the FS-53 economic module, and the demographic, subarea allocation, and ED interface modules of SEARS and/or PAS. Regardless of the improvements that may be made to SEARS during its upcoming revisions, this hybrid model is expected to be the best option because of the unique strengths of the FS economic module. As can be seen from examination of Table 2, the rating of the hybrid model is above any of the three stand-alone candidate models. The superior rating of the hybrid model under a wide range of potential criteria weights is an important result of the analysis. Comparisons of the rankings of the three stand-alone models under alternative weight assumptions indicated that relative rankings could change under plausible weight assignments. However, with regard to the hybrid model, the higher rating is not sensitive to alterations in the weights assigned to each criterion, unless criteria regarding documentation clarity or ease of data input are weighted far more heavily than shown in Table 2.

The selection of the hybrid model as the preferred model, rather than the SEARS or PAS models, also allows BWIP to progress immediately. Neither SEARS nor PAS will be available until at least the latter half of FY 88. The FS portions of the hybrid model, however, can be available almost immediately so that model development and validation can begin. However, should the FS economic or demographic modules prove insufficient, other modules from SEARS or PAS can be substituted. Selection of SEARS or PAS would require deferring all model development work until late FY 88, which would not be consistent with BWIP objectives.

6.2 EVALUATION DECISION

A hybrid model will be used for BWIP. An FS-53 model will be calibrated for the Benton-Franklin County area; further evaluation and testing will be devoted to linking the FS-53 model to SEARS, PAS, and/or modules developed by the Human Affairs Research Center (HARC) to allocate population, employment, and other outputs to subcounty jurisdictions. The FS-53 demographic and labor market modules will be tested to determine whether or not their use would be advantageous. As noted earlier, the FS-53 approach appears promising but requires further evaluation.

An FS-53 model will also be purchased for the State of Washington, in order to identify inter-regional flows between Benton and Franklin Counties and the rest of the state. In addition, an eastern Washington model, models for the counties in which affected tribes are located, a state 500-sector I/O model, and a quarterly version of the FS-53 model will be evaluated for purchase during early FY 1988.

7.0 UNSOLVED ISSUES AND STEPS TO RESOLVE THEM

The goals for FY 1987 are to 1) begin validating the FS models and 2) produce economic, demographic, and fiscal profiles. Linkage of the PAS or SEARS and FS-53 models will not be possible by the end of FY 1987. This is because the PAS model vendor estimates 4 to 6 months to produce a reprogrammed version that is compatible with the FS-53 model and HARC hardware, and the SEARS model vendor will not complete revisions until FY 1988. However, validation of the FS models for the State, and Benton and Franklin Counties is planned to commence during FY 1987.

Given unavoidable uncertainty regarding the success of validating the FS-53 model, the primary step to be resolved for FY 1987 is forming a backup strategy for developing an ED model that meets BWIP objectives if the FS-53 model proves inadequate. The major ED modeling step for FY 1988 is developing a hybrid model to address demographic and subarea assessment needs.

Once working FS models have been installed on the project computers, FS-53 model validation will commence. A data set consisting of demographic and economic indicators will be assembled, and pre- and post-1981 periods for validation will be selected. The model will then be run to determine 1) whether or not it can replicate historical data, and 2) the steps required to remedy any deficiencies.(a)

(a) The best validation method is the comparison of "out-of-sample" forecasts to actual data. This procedure is difficult to implement with FS models, since they are generally calibrated on the most current available data. It will not be possible to perform out-of-sample tests without considerable additional cost. Thus, in-sample validation may have to suffice.

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APPENDIX

ED MODEL RATING DOCUMENTATION

APPENDIX

ED MODEL RATING DOCUMENTATION

The following is a description of the basis for the ratings presented in Table 2. These ratings are based upon the current version of the SEARS model. Since the model is currently undergoing revision, the ratings are tentative. The ratings for the REMI demographic/labor market interface module, which has not yet been released in its entirety and requires field testing, are also tentative, and an attempt has been made to assign conservative ratings to that model to reflect uncertainty regarding its usefulness for the BWIP.

A.1 SOUNDNESS OF THEORETICAL BASIS (WEIGHT: 0.2)

A.1.1 Economic Module

The best model is the FS-53 model. It uses both input and output tables, which clearly represent the relationships between sectors, including indirect basic activities, as well as the Regional Purchase Coefficient method of calibrating local I/O tables from national (or in the case of Washington, state) data. Furthermore, the FS-53 model can address price changes and structural change over time.

Although the SEARS model also is based on an I/O matrix, local calibration of national or state tables is apparently done by the Location Quotient method, which ignores cross-hauling. The SEARS model also does not permit price-related structural change, although technological advance can apparently be simulated with some effort.

The PAS model is based on modified basic and nonbasic multipliers, which are difficult to define, and allows no price or structural change. It is therefore considered the least desirable of the three models.

RATINGS: PAS: 4 FS-53: 10 SEARS: 6

A.1.2 Demographic Module

All three demographic modules are based on cohort-survival procedures, which are well accepted in theory. The ratings are a function of the number of options available; PAS has the most options for testing vital rates, and FS-53 has fewest.

RATINGS: PAS: 5 FS-53: 3 SEARS: 4

A.1.3 Labor Market Module

The PAS and SEARS modules both operate in a similar fashion, with local labor supplies compared to labor demand, and migration balancing the market. Both use similar concepts to define "threshold excess demand/supply" for labor, at which level migration is initiated. PAS is considered slightly better in that labor demand and supply is explicitly considered at the county level, rather than at the community level as in SEARS; however, the SEARS documentation is unclear on this point. The FS-53 model specifies migration in a more theoretically grounded fashion, by an econometric equation relating economic migration to wages and employment opportunities in the study area relative to the United States, thereby avoiding the problem of "lumpy" migration in the other two models. However, the FS-53 approach has not been tested. The lower rating for the FS-53 model, and the higher ratings for the PAS and SEARS models, could be changed upon further testing.

RATINGS: PAS: 5 FS-53: 3 SEARS: 4

A.1.4 Subcounty Allocation Module

Since the theory of subcounty allocation is not well developed (few models exist that have performed well in explaining residential location decisions), it is difficult to rate SEARS and PAS. PAS allows users to define their own theory of subcounty allocation, while SEARS provides the option of a fairly elaborate gravity model. While gravity modeling is common, such models have not been very successful in explaining residence location. The primary reason for rating SEARS' subcounty allocation module below that of PAS is the implication in the SEARS documentation that only incorporated areas can be defined, while

PAS permits definition of rural subareas as well. FS-53 models have no subcounty allocation module.

RATINGS: PAS: 5 FS-53: 0 SEARS: 4

A.2 RELEVANCE TO BWIP INFORMATION REQUIREMENTS (WEIGHT: 0.15)

A.2.1 Economic Module

The FS-53 model provides 53-sector detail, corresponding largely to the 2-digit SIC level of detail (which will be useful for fiscal impact analysis), and produces information on 94 occupations, in addition to producing all standard economic indicators (employment, income by source, etc.). The price outputs may also be useful in risk assessment. The SEARS model produces only 27-sector detail and very little occupational information. The PAS model produces only 1-digit SIC detail and no occupational information, but does produce unemployment forecasts (although they are of dubious accuracy).

RATINGS: PAS: 4 FS-53: 10 SEARS: 7

A.2.2 Demographic Module

The SEARS module is rated highest since it can address special populations such as Indian tribes; outputs are otherwise similar to, but slightly more detailed than, those of PAS. The FS-53 module produces only age and sex estimates.

RATINGS: PAS: 4 FS-53: 3 SEARS: 5

A.2.3 Labor Market Module

Information required for BWIP includes migration for employment and nonemployment reasons, demographic characteristics of migrants (for housing and other purposes), and unemployment rates. PAS provides all of this information. SEARS apparently produces all except unemployment rates, and FS-53 models produce all except noneconomic migration and unemployment rates.

RATINGS: PAS: 5 FS-53: 3 SEARS: 4

A.2.4 Subcounty Allocation Module

Subcounty allocation of population and jobs is an important issue for BWIP. Information required includes population and employment-by-sector for cities, and probably for some rural unincorporated subareas, too. PAS is considered superior to SEARS since the SEARS documentation does not address rural subareas, but both models provide population and employment by sector, as well as demographic characteristics, for incorporated areas. The FS-53 model does not have subcounty allocation modules.

RATINGS: PAS: 5 FS: 0 SEARS: 4

A.3 SUITABILITY TO LOCAL ECONOMY (WEIGHT: 0.15)

A.3.1 Economic Module

The primary issues regarding suitability are the existence of a number of simultaneous projects that are expected to require a scenario approach to forecasting, the dominance of federal activites, and the need for accurate modeling of economic downturns and upturns. All three models provide ways for combining elements of scenarios and identifying differential effects of various projects.

The dominance of federal activities in the Tri-Cities, and the potential for substantial changes in it that will greatly affect the impacts of the BWIP, underscore the importance of this sector. The PAS model, which provides economic information for only 11 sectors, has relatively rudimentary abilities to handle federal activities (especially since some "government" employment, such as at the PUREX facility, is actually classified in the data as private manufacturing or services employment). The FS-53 model provides detailed estimates of purchases by 53 economic sectors (estimates that could be improved to the 500-sector level of detail). The SEARS model is judged to lie midway between the PAS and FS-53 models, since it defines 27 sectors.

Modeling economic downturns as well as upturns can probably be done by all three models with some effort devoted to good specification

of migration trends and careful examination of economic sectors most vulnerable to government-related actions. Both REMI and PAS have been used to derive impacts of plant closures, but SEARS has no track record.

RATINGS: PAS: 5 FS-53: 10 SEARS: 7

A.3.2 Demographic Module

Neither the PAS nor SEARS models are felt to have an advantage, since they produce similar outputs. The lack of race detail for the REMI model is considered disadvantageous.

RATINGS: PAS: 5 FS-53: 3 SEARS: 5

A.3.3 Labor Market Module

The primary need is an ability to model economic downturns because migration patterns are probably not symmetric. Neither the PAS nor SEARS model has a clear advantage in this regard, since both use similar procedures to trigger migration. It is expected that both models would have to be improved to accurately model out-migration. The REMI model also seems incapable of addressing out-migration very well, but lack of documentation on the labor market model makes it difficult to confidently assign a rating.

RATINGS: PAS: 5 FS-53: 4 SEARS: 5

A.3.4 Subcounty Allocation Module

The only known issue for the Tri-Cities economy that may be of concern is the relationship of the two counties. Barriers to travel between the two counties (such as the Columbia River) may invalidate SEARS' air-distance calculations for the gravity model, but the presence of the gravity model option is a convenience not available in PAS. Thus, the two models are rated equal. The FS-53 model has no subcounty allocation module.

RATINGS: PAS: 5 FS-53: 0 SEARS: 5

A.4 CLARITY OF DOCUMENTATION (WEIGHT: 0.10)

Clarity of documentation refers to both the quality of user manual and on-line screen prompts. FS-53 model documentation is extensive, and REMI provides documentation geared to the user for every source code they sell. Annotated source code listing is included, and REMI models are the subject of much explanation in various technical journals. The documentation is generally well presented, and includes instructions to help users respond to prompts.

PAS model documentation is brief and vague, with no annotated source code. However, the PAS model's BAS system is an excellent data manager, with good guidance provided to the user on-line.

The SEARS model has voluminous technical documentation, but it is not well organized and is difficult to comprehend. Screen prompts to assist the user in file management do not exist.

RATINGS: PAS: 4 FS-53: 5 SEARS: 4

A.5 EASE OF CORRECTING DEFICIENCIES (WEIGHT: 0.20)

The FS-53 model is clearly the best of the three models, primarily because it is written in a common language, FORTRAN, and has relatively easy-to-understand structure. Most of the FS-53 model's deficiencies are omissions of modules (which can be "ported" onto the model relatively easily) rather than deficiencies within complex pieces of existing modules, which can be difficult to correct.

The PAS model is the next best, based primarily on Mountain West's commitment to write the model in FORTRAN. The SEARS model, on the other hand, is written in APL, which is not a common language. Changing both models would require extreme care to ensure that changes in one line of code do not cause undesirable chain effects in other areas.

RATINGS: PAS: 4 FS-53: 5 SEARS: 3

A.6 EASE OF DATA INPUT (WEIGHT: 0.05)

The FS-53 model is again preferred because its input data requirements are far less demanding than the other models. Data input for PAS is straightforward with the BAS system, but other files are also needed, for which few user prompts are available to avoid errors and confusion. The SEARS model, judging from the documentation, has extensive data requirements, and user prompts to assist in data entry are apparently few. Thus, the SEARS model is rated lowest; it is substantially below FS-53 but only slightly below PAS.

RATINGS: PAS: 3 FS-53: 5 SEARS: 2

A.7 CLARITY OF PRESENTATION (WEIGHT: 0.05)

All models provide a variety of summary and detail tables that are apparently well organized; therefore, no appreciable differences exist.

RATINGS: All are assigned scores of 5.

A.8 AVAILABILITY AND TIMING (WEIGHT: 0.10)

The FS-53 model is available immediately (generally, with a 1-month turnaround time from the date of order). Neither the PAS nor the SEARS models would be available before the latter part of FY 88.

RATINGS: PAS: 4 FS-53: 5 SEARS: 4

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